Comparisons of U.S. and Japanese R&D Policies[*]

Dr. Gregory Tassey

Strategic Planning and Economic Analysis Group
National Institute of Standards and Technology
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For most of the post-war period, U.S. and Japanese technology policies have evolved in opposite directions. Different economic growth trajectories and different cultural and philosophical views regarding the role of government in promoting economic growth have shaped each nation's R&D policy. In recent years, however, a partial convergence in economic strategies has led the two countries toward a single conceptual model of what constitutes a successful, national R&D system. The policies derived from this model have also tended to converge. There remains, however, an opportunity for both Japanese and American policymakers to understand better the economic forces that create a need for government funding of R&D and thereby to permit the development of efficient national R&D programs.

The United States

In the United States, as World War II was ending, the director of the President's Office of Scientific Research and Development Vannevar Bush undertook a study of how the results of wartime research could be used to promote prosperity and full employment. The result was *Science—The Endless Frontier* presented to President Truman in July 1945. This report identified scientific knowledge as a *national* resource.

The Bush report's emphasis on the importance of basic research to achieve national goals led to the establishment of the government-funded National Science Foundation (NSF) to support scientific research for societal benefit, including economic growth. Under this framework, government supported *science* while industry developed *technology*. With the exception of spin-offs to commercial applications from mission-oriented government R&D (defense, space exploration, etc.), this relatively simple model drove U.S. technology and economic growth policies.

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The "Bush" model, which is more a philosophy than a plan, has not proved adequate for today's technology policy debates. A more rigorous economic model is needed. Many of the ongoing arguments in the United States over the existence and causes of various "market failures" which justify a government-directed "S&T" policy have been both emotional and analytically weak. Even the partial economic arguments that have been developed are frequently ignored by participants in this debate.

The R&D policy process is also unable to absorb today's highly technical, decision-relevant information such as analyses of the causes of specific underinvestment patterns. This situation has led to difficulty in reaching a consensus on policy initiatives and has created instability in the policies that are implemented. The inconsistent management of the R&E (Research and Experimentation) tax credit and the contradictory attacks on NIST's Advanced Technology Program (ATP) exemplify the problem.

The R&E tax credit, for example, was designed to stimulate a targeted portion of overall R&D—the early ("experimental") phases which entail higher levels of risk. This credit is 20 percent of the increase in a company's qualified R&E expenditures, where the increment is calculated from a base R&E expenditure derived by multiplying an average R&E-to-sales ratio for the years 1984-88 by sales in the tax year. However, in spite of the intended emphasis on "research and experimentation," a large portion of R&D conducted by industry ended up eligible. Whether this result was good or bad is a different issue from the one of the feasibility of using tax incentives for specific types of R&D.

Economic studies indicate that for every dollar lost in tax revenue, the R&E credit has produced a dollar increase in reported R&D spending, at the margin. One can therefore say that a tax incentive is an effective policy instrument and, if sufficiently large, can meaningfully expand industry investment in R&D. However, because of the way tax incentives affect R&D investment decision making, the impact is on the existing strategy of the firm and thus, this policy mechanism "represents more of a financial tool than a technology tool." [1] As a financial tool, a tax incentive for R&D is best applied to broader market failures; that is, when aggregate R&D of the type already being conducted is deemed inadequate.

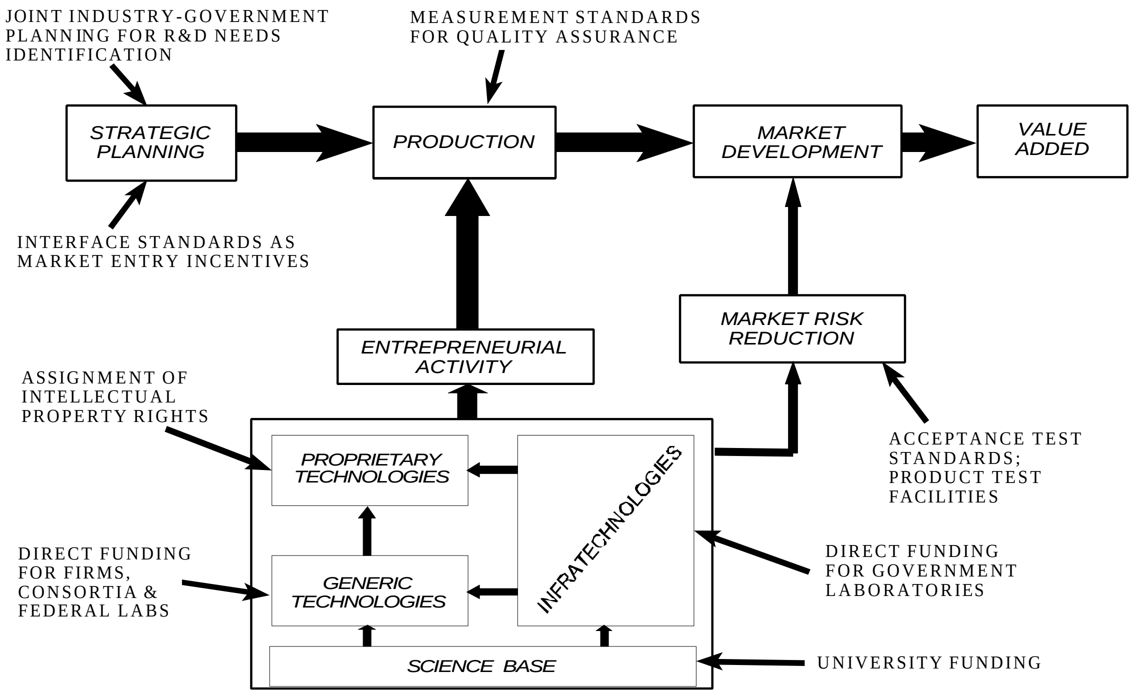
Direct funding of R&D has been used for decades in many industrialized nations for quite different purposes. Until the 1990s, most direct funding programs in the United States supported nonmarket missions (national defense, space exploration, environmental quality). However, government R&D funding mechanisms for economic growth purposes have evolved significantly in the past decade around the world. The European Union's (EU's) Framework Program, several Japanese programs, and NIST's ATP in the United States integrate corporate and government strategic planning through cost-sharing requirements in order to increase the effectiveness of this general policy instrument.

Most direct funding assistance is provided to the private sector on a cost-shared basis in areas of technology that have both high potential economic benefits and unusually high technical and market risk. The ATP in the United States and comparable programs elsewhere focus on the

[1] U.S. Congress, Office of Technology Assessment [1995, p. 7].

early phases of technology research. Such generic technology research funding by industry is often inadequate due to the market failures associated with high technical risk, long expected time to commercialization, and highly uncertain scope and magnitude of potential markets. Moreover, other elements of an industrial technology have a strong infrastructure character, which inhibits R&D funding decisions. These elements include measurement and test methods, data formats, and the technical bases for interfaces between components in a system (such as a communications or factory automation systems). These *infratechnologies* often become the basis for industry standards and are therefore only of economic value if widely used. Common use, however, means no one company will invest in the infratechnology.

Figure 1
R&D-Related Policy Mechanisms



source: Tassey [1997, Chap. 6]

As indicated in Figure 1, each market failure requires a unique policy mechanism. Thus, cost-shared funding of generic technology research, national laboratory conduct of infratechnology research, regional centers for technology transfer to small and medium firms, and government assignment of IP rights are all part of an overall microeconomic policy structure.

In Japan

In Japan, a different objective drove government R&D policy in the 1970s: the national mission was to "bootstrap” domestic industries up to world standards. One example was the highly successful VLSI Project, which ran from 1976 to 1979 and was funded by the Ministry of International Trade and Industry (MITI). This effort propelled the Japanese electronics industry up to and eventually past the U.S. semiconductor industry in the development of important semiconductor device technologies and beyond U.S. companies in consumer electronics. Such policies targeted *applied R&D* because increasing individual company R&D capabilities was the objective. By implication and by fact, the technology basis for this applied R&D came from foreign sources. Because applied R&D is typically many times the cost of earlier phases of generic technology research, these catch-up policies were more expensive to implement than programs focusing on the latter type of research.

As Japan's industries achieved world class status in the 1980s, government policy began to shift toward a focus on the earlier phases of R&D. This change toward objectives similar to the U.S. and European programs resulted from the realization that Japanese companies needed to prepare for subsequent technology life cycles in advance rather than continually rely on the "catch-up" strategy of the 1970s. Moreover, Japanese companies that had attained world class status were no longer interested in sharing their now considerable applied (market-focused) R&D capabilities by participating in government-led consortia. MITI's Next Generation Project and more focused programs such as the Fifth Generation Computer Project are examples of early attempts to shift government research programs toward the early (generic) phases of technology research.[2] A corollary policy objective was to increase basic scientific research and thereby provide an internal science base that could make contributions to Japanese industrial technology research, help achieve social objectives requiring technology development, and support the global scientific community.

In the 1990s, the evolution of Japanese R&D policy has continued. The Next Generation Project was combined with the older Large Scale Project to form the Science and Technology Frontier Program. MITI's Agency for Industrial Science and Technology (AIST), which had previously subsidized university research, research institutes, and already-established R&D projects in individual companies and consortia, launched programs such as the System to Support Development of Creative Technology for New Industries (begun in 1996 at $35 million per year) which target radically new technologies and industries. Such programs are also part of a strategy to promote regional economic growth based on specific new technologies and industries.

Japan's so-called "S&T Basic Law" (officially, the *Law for the Orientation of Science and Technology*) was implemented in 1996 to achieve "a higher standard of science and technology." The impetus for the law was the perception that Japan "needs to boldly challenge unknown fields of S&T on its own initiative." More specific motivations were the decline of Japanese R&D spending in the 1994-96 period and the "growing expectations for basic research, which is valuable in itself as intellectual property for all humans to share."[3]

However, the real driving force seems to be the realization that R&D systems in Japan "tend to lack flexibility and competitiveness." This driving force is reflected in the major tenets of the Basic Law, which target not just expansion of R&D but new foci such as more creativity, sectoral and regional integration of R&D activities, promotion of cooperative research mechanisms, and

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2 Japanese S&T policy documentation does not always distinguish between basic or *scientific* research and early-phase or generic *technology* research. Instead, the two are lumped together which is unfortunate from a policy analysis perspective. See, for example, Odagiri et al [1997].

3 Translation of internal memorandum (March 1, 1998) provided to the author by the Planning Division, Science and Technology Agency.

more liberal assignment of intellectual property rights. An additional and original feature is the requirement for the first time to develop and systematically apply "fair and strict" evaluations of government R&D.

Convergence?

Table 1 provides samples of U.S. and Japanese R&D support programs (along with comparable ones in the European Union). The programs are grouped by category of market failure and associated types of policy response mechanisms.

Although R&D policy objectives appear to be converging in the United States and Japan, pronounced differences persist due to different implementation philosophies and differences in domestic industry structures that absorb R&D project results. In the 1980s, the United States and Europe realized that, because the policy objective of their new programs (ATP and Framework, respectively) was to broaden and accelerate development of generic technologies to expand or create industries, an essential outcome must be rapid and broad diffusion of the intellectual property (IP) that results from each research project. Previous philosophies that government should own the IP and then license it were discarded in favor of the stronger incentives for follow-on applied R&D provided by direct assignment of IP to private sector participants in a project. Furthermore, because both programs co-fund projects with industry, IP ownership by private sector companies is a necessary incentive for their participation. Japan, however, has only reluctantly moved in this direction. The Japanese government continued to hold all IP rights from joint research projects with industry until 1991, when it allowed private sector participants to own up to 50 percent of the resulting IP. Under the 1996 S&T Basic Law, patent rights can now be granted to individual researchers at national research institutions, and prior assignment of IP rights can be made to research institutions that conduct joint research or contract research on behalf of government organizations.

Most industrialized nations use one or more tax incentives for R&D, and the United States and Japan are not exceptions. However, while the U.S. 20 percent incremental R&E tax credit remains controversial, Japan seems to have permanently institutionalized several tax incentives for R&D with little ongoing debate. The Japanese also have an incremental 20 percent tax credit for R&D expenses exceeding the highest previous year's expenditure (up to a maximum of 10 percent of total corporate tax). In addition, Japan allows small and medium-size firms to deduct six percent of all R&D expenses up to a maximum of 15 percent of total corporate tax. To promote cooperative R&D, a six percent tax credit is offered for R&D expenses incurred in joint projects with national research institutes. Japanese firms also benefit from accelerated (one-year) depreciation of equipment used in joint R&D projects.

Table 1

National R&D Policies by Market Failure/Policy Category

(with approximate national government contribution to FY96 or FY97 annual budget)

	Risk, Time to Market, Scope of Markets: ***Generic Technology***	**Collective Use, Industry Structure, Transaction Costs:** ***Generic Technology, Infratechnology***	**Technology or Market Strategy Mismatch:** ***Proprietary Technology***
United States	NIST: ATP (50% cost sharing with consortia; direct R&D costs for single firms) — $220M	NIST: laboratory research (some cost-shared consortia) — $260M; some ATP projects	In-kind support (CRADAs) and direct funding (SBIR) for projects with individual firms
Japan	MITI: Industrial Science and Technology Frontier Program — $230M; System to Support Development of Creative Technology for New Industries — $35M	MITI: laboratory research (some collaborative research) through 15 AIST laboratories — $440M	Key Technology Center (70% cost-sharing of joint ventures) — $225M
European Union	Framework IV Program (50% cost sharing) — $3,000M; $1,500M for “enabling” technologies; country programs (e.g.: Germany — $1,300M)	Individual country laboratories; e.g.: Germany — $320M, U.K. — $75M	EUREKA (35% cost share) — $1,200M; individual country programs (Fraunhofer Institutes — $200M of $650M total budget)

With respect to industry structure, U.S. technology-based industries have a more dynamic character and therefore adapt relatively well to the requirements of new generations of technology. The structures of Japanese high-tech industries, on the other hand, tend to be more rigid and thus less amenable to adjustment when radically new technologies appear. For example, in the 1970s, both U.S. and Japanese computer industries were dominated by mainframe companies that bundled sales of these machines with customized software. In the 1980s, the dynamics of the U.S. economy allowed the emergence of a personal computer industry driven by new companies, such as Apple Computer. The existence of many small, innovative companies in the United States was made possible by a cultural endorsement of entrepreneurial activity and a supporting venture capital infrastructure. Such dynamics, in turn, forced strategic changes by the older mainframe companies such as IBM. This evolution of industry strategy and structure was further abetted by the simultaneous evolution of a standards infrastructure.

Japanese industry was not able to make the same transition. Factionalism among the *keiretsu* thwarted standardization on an operating system for computers, in spite of MITI's Sigma Program (1985-90) and a five-year extension (SuperSigma). Japanese industry with a number of university partners has also attempted to develop a new standard operating system through the TRON Project, but this effort has been thwarted by the failure of a major computer firm, NEC, to participate (NEC earlier invested in compatibility with U.S. standards and was therefore not interested in trying to set a new Japanese standard).

In addition, a cultural bias against entrepreneurial activity significantly retards the emergence of new firms. Although MITI continues to refocus R&D on the promotion of new technologies by young companies as part of a regional economic growth strategy, success will require national acceptance and, in fact, admiration of "startups," even when they fail. Moreover, the lack of an adequate venture capital infrastructure has been recognized as far back as the mid-1980s, when MITI and the Ministry of Posts and Telecommunications (MPT) launched the Japan Key Technology Center (JKTC) Program. The JKTC funds up to 70 percent of total costs of an industry research partnership for up to seven years. It therefore operates as a government venture capital entity. However, a recoupment philosophy is followed under which the government's investment can be returned through either the sale of its equity interest or the payment of royalties. Such a strong disincentive probably explains why only 60 projects were funded in the first ten years. The United States initially included a recoupment provision in ATP, but rescinded it because of its negative incentive effects.

Policy Differences & Similarities

Many of the new R&D policy initiatives in Japan focus on early-phase generic technology research to provide the basis for the radically new technologies and industries of the future. These recent programs also include a standardization strategy in an effort to coordinate the development of new technologies with the required standards. The greater focus on funding R&D in small and medium-size firms may increase entrepreneurial activity and thus begin to close the gap with the United States with respect to facilitating dynamic industry structures.

However, it remains to be seen if these initiatives can effectively remove the several market failure mechanisms identified here that persist in Japan's high-tech industries. In the 1990s, macroeconomic problems have weighed heavily against investment in general, as evidenced by the recent three-year decline in private sector R&D spending (1994-96)—the first such decline since R&D data were first collected in the 1950s.

The importance of national R&D programs that are both broad in scope and efficient in terms of targeting the appropriate market failures that retard economic growth has been persistently underestimated in most industrialized nations, including the United States and Japan. The reasons why policy makers have under-emphasized this critical area of economic growth policy are several. First and foremost, policy makers and even economists who influence growth policies suffer from an inadequate understanding of the typical technology life cycle described earlier. Numerous elements of any industrial technology have public good characteristics which means systematic underinvestment will and does occur.

Second, because of this lack of understanding, the typical S&T policy exercise, whether conducted by a government, industry or academic group (or some combination of these three) is base on two assertions: (1) technology is essential, and (2) systematic underinvestment occurs in at least one phase or type of R&D. Without sufficiently documenting both of these assertions, the proponents of outdated policy models can be successful at blocking needed policy changes and initiatives.

Third, the S&T and economic growth policy mechanisms in the two countries are inexplicably separated. Technology is clearly a critical input to sustained economic growth and therefore S&T policy should be an integrated subset of the broader economic growth policy process. However, this is still not the case in either country, in spite of recent efforts to promote such integration.

One of the most serious manifestations of the policy dysfunction caused by these three factors is the false argument by opponents of government R&D that technology is basically a homogeneous commodity and thus produced by only one sector—private industry. Statements by noted economists such as Paul Krugman that "nations do not compete, companies do" are inaccurate and have been used as arguments against needed policy adjustments. There is plenty of evidence that the location of R&D and subsequent capital investment decisions are strongly influenced by the quality of available technical infrastructure, including universities, national laboratories, research institutes, and institutional mechanisms for promulgating technical standards. In addition, the availability of skilled labor is a critical factor in location decisions.

The key point is that both technical infrastructure and skilled labor are immobile economic assets. That is, they are not easily diffused or otherwise moved across national boundaries. In fact, within a national economy different potential and actual growth rates can be explained to a significant extent by regional differences in these assets. Japan, in particular, seems to realize this fact and has implemented a number of policies in recent years to support investment in regional technical infrastructure. In summary, increasing value-added within the domestic economy at both the R&D and manufacturing stages is a frequently stated policy objective, but the underlying economic forces enticing the needed investment, both foreign and domestic, are not understood.

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Dr. Gregory Tassey
National Institute of Standards and Technology
Admin 100
Gaithersburg, MD 20899
(301) 975-2663
Fax: (301) 216-0529
E-mail: gtassey@nist.gov

Biographical Information

Dr. Gregory Tassey is a Senior Economist at the National Institute of Standards and Technology. He analyzes the economics of high-tech industries and conducts policy research, including technology-based growth analyses, economic impact of standards, and comparative analyses of foreign government programs for industrial innovation and international competitiveness. He is the author of *Technology Infrastructure and Competitive Position* (1992) and *The Economics of R&D Policy* (1997). Dr. Tassey received his B.A. in Physics from Western Maryland College and his Ph.D in Economics from The George Washington University.